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February 1989

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WADA1: FORTRAN PROGRAM FOR
WAVE DIFFRACTION ANALYSIS -
VERSION 1

Samon Ando

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WAVE DIFFRACTION ANALYSIS -
VERSION 1

Samon Ando

February 1989

Approved by L.J. Leggat

Director/Technology Division

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ABSTRACT

This technical memorandum describes the FORTRAN computer program WADA1 (WAVE Diffraction Analysis—version 1), which calculates the pressure induced by the diffraction of regular incident waves on arbitrary-shaped two-dimensional cylinders fixed in the free surface of deep water. Based on the source-distribution method, WADA1 solves the integral equation for the linear diffraction problem by Frank's close-fit method.

RÉSUMÉ

Le présent rapport technique décrit le programme FORTRAN WADA1 (analyse de la diffraction des vagues, première version) qui permet de calculer la pression induite par la diffraction de vagues incidentes régulières sur des cylindres à deux dimensions et de formes arbitraires fixés à la surface libre d'eaux profondes. En faisant appel à la méthode de distribution des sources, le programme WADA1 résout l'équation intégrale du problème de diffraction linéaire au moyen de la méthode de l'ajustement fin de Frank.

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NOTATION

a	amplitude of incident wave
B	breadth of cylinder at waterline
G	Green function
g	gravitational acceleration
I_{ij}	influence coefficients
Im	imaginary part of a complex variable
K_{ij}	integral of $\partial G / \partial n$ along S_j for field point located at the i^{th} node
k	dummy variable for integration
\mathbf{n}	normal unit vector to S pointing out of fluid
\mathbf{n}_i	normal unit vector to S_i ; $\mathbf{n}_i = (n_{i1}, n_{i2})$
n_{i1}, n_{i2}	x - and y -components of \mathbf{n}_i
P_I	time-dependent incident-wave pressure ($= p_I e^{-i\omega t}$)
P_D	time-dependent diffracted-wave pressure ($= p_D e^{-i\omega t}$)
P_W	time-dependent total wave-induced pressure ($= P_I + P_D$)
P.V.	Cauchy principal value
p_I	complex amplitude of incident-wave pressure
p_D	complex amplitude of diffracted-wave pressure
Q	source strength
Q_j	source strength for the j^{th} segment S_j
Re	real part of a complex variable
S	cylinder contour below calm-water line
S_i	i^{th} segment of S
s	length variable along S
T	draft of cylinder
t	time
U_i	normal velocity of incident wave at S_i
x, y	coordinates of a field point
z	complex variable ($= x + iy$), or a coordinate
β	wave direction relative to the z -axis
δ_{ij}	Kronecker delta function
Γ_{ij}	integral of G along S_j for field point located at the i^{th} node
ζ	complex variable ($= \xi + i\eta$)

$\bar{\zeta}$	complex conjugate of ζ
ξ, η	coordinates of a source point
ξ_B	frequency parameter ($= \nu B/2$)
ν	wave number ($= \omega^2/g$)
ρ	mass density of fluid
Φ_I	time-dependent incident-wave potential ($= \varphi_I e^{-i\omega t}$)
Φ_D	time-dependent diffracted-wave potential ($= \varphi_D e^{-i\omega t}$)
Φ_W	time-dependent total potential ($= \Phi_I + \Phi_D$)
ϕ	phase angle between wave-induced pressure and incident wave
φ_I	complex amplitude of incident-wave potential
φ_D	complex amplitude of diffracted-wave potential
ω	wave frequency
∇	gradient operator

Superscript

(m)	mode of pressure excitation
$m = 1$	horizontal excitation (asymmetric about the y axis)
$m = 2$	vertical excitation (symmetric about the y axis)

Subscripts

i, j	indices for contour segments
n	indices for irregular frequencies

1. INTRODUCTION

This technical memorandum describes the FORTRAN computer program WADA1 (Wave Diffraction Analysis—version 1) developed as part of DREA's on-going research to analyze the interactions of ocean waves with marine vehicles. WADA1 calculates the hydrodynamic pressure induced by an incident sinusoidal wave and diffracted wave on arbitrary-shaped two-dimensional cylinders fixed in the free surface of deep water.

WADA1 solves the linear diffraction problem by the source-distribution method. It uses the Green function that is a particular fundamental solution of the two-dimensional Laplace equation and directly satisfies the boundary conditions on the free surface, on the sea bottom, and at infinity. The amount of required input data is minimal since only the boundary condition on the body surface remains to be satisfied; however, the computation of the Green function and its gradient is complicated. Also the method fails to give a unique solution at "irregular frequencies," but these usually occur outside the range of frequency of practical interest.

The mathematical formulation of the linear diffraction problem is described in Section 2. The solution technique adopted in WADA1, a simple collocation method originally used by Frank¹, is outlined in Section 3. Comments on the "irregular frequencies" are made in Section 4. Descriptions of the input and output are given in Sections 5 and 6, respectively. Concluding remarks are given Section 7. Sample input and output are included in Appendices.

2. STATEMENT OF THE MATHEMATICAL PROBLEM

The water is assumed to be deep and inviscid, and its motion irrotational. The wave amplitude is assumed to be small compared with a characteristic length of the body, say, the half-breadth of the cylinder, so that linearization is valid. In Fig. 1, the Cartesian coordinates (x, y, z) are fixed to the cylinder, which is assumed to be of infinite length in the z -direction with a uniform cross section. The xz -plane lies in the calm-water surface. The y -axis points vertically upwards. The origin is located at the midpoint of the breadth B of the cylinder at the calm-water line. The cylinder contour below the calm-water line in the xy -plane is denoted by S . The direction of propagation of the incident wave, the sinusoidal wave of frequency ω , is at an angle β to the z -axis.

In the linear diffraction problem, which WADA1 solves, the total wave potential Φ_W is separated into the incident-wave potential Φ_I and the diffracted-wave potential Φ_D :

$$\Phi_W(x, y, t) = \Phi_I(x, y, t) + \Phi_D(x, y, t). \quad (1)$$

The incident-wave potential is given by

$$\Phi_I(x, y, t) = \varphi_I(x, y)e^{-i\omega t} \quad (2)$$

with

$$\varphi_I(x, y) = -i \frac{ga}{\omega} e^{\nu y} e^{-i\nu x \sin \beta} \quad (3)$$

where $i = \sqrt{-1}$, t is the time, a is the amplitude of the incident wave, g is the gravitational acceleration, and $\nu = \omega^2/g$ is the wave number. Here and in the following, it is to be understood that only the real parts of complex expressions are to be taken.

The diffracted-wave potential is assumed to be of the form,

$$\Phi_D(x, y, t) = \varphi_D(x, y)e^{-i\omega t} \quad (4)$$

where φ_D is the solution of the Laplace equation:

$$\frac{\partial^2 \varphi_D(x, y)}{\partial x^2} + \frac{\partial^2 \varphi_D(x, y)}{\partial y^2} = 0 \quad \text{in the fluid domain, } y \leq 0 \quad (5)$$

and satisfies the following boundary conditions:

$$\frac{\partial \varphi_D}{\partial y} - \nu \varphi_D = 0 \quad \text{on the free surface, } y = 0 \quad (6)$$

$$\lim_{y \rightarrow -\infty} \frac{\partial \varphi_D}{\partial y} = 0 \quad \text{on the sea bottom} \quad (7)$$

$$\lim_{x \rightarrow \pm\infty} \left\{ \frac{\partial \varphi_D}{\partial x} \mp i\nu \varphi_D \right\} = 0 \quad \text{at infinity (radiation condition)} \quad (8)$$

$$\frac{\partial \varphi_D}{\partial n} = -\frac{\partial \varphi_I}{\partial n} \quad \text{on the body surface } S(x, y) = 0. \quad (9)$$

In Equation (9), $\partial/\partial n = \mathbf{n} \cdot \nabla$ denotes the derivative in the direction of \mathbf{n} , the vector normal to the surface and pointing into the body. Except for the body-boundary condition (9), the above boundary-value problem is identical to the strip-theoretical radiation problem in which the right-hand side of Equation (9) is replaced by the prescribed velocity of the body surface.

In oblique waves, φ_D should depend on the z -coordinate as well as on the x - and y -coordinates, but the dependence of φ_D on the z -coordinate is neglected in the two-dimensional mathematical model (5)–(9). As a result, the diffraction pressure predicted by WADA1 is expected to become less reliable as the direction of propagation of the incident wave deviates away from that of the beam wave towards those of the head or following waves, that is, $|\beta - \pi/2| \rightarrow \pi/2$.

3. SOLUTION TECHNIQUE

A common scheme of solving the radiation and diffraction problems is the source-distribution method using the Green function $G(x, y; \xi, \eta)$ that defines a velocity potential at a field point (x, y) owing to a source of unit strength located at a point (ξ, η) . If the strength of the source is $Q(\xi, \eta)$, then by the assumption of linearity, the velocity potential at (x, y) is $G(x, y; \xi, \eta)Q(\xi, \eta)$. Using a Green function, the diffracted-wave potential $\varphi_D(x, y)$ can be expressed in terms of a distribution of sources of strength $Q(\xi, \eta)$ on the immersed surface S of the body under the calm water line; that is,

$$\varphi_D(x, y) = \int_S G(x, y; \xi, \eta) Q(\xi, \eta) ds(\xi, \eta). \quad (10)$$

Implicit in Equation (10) is the dependence of φ_D on ν and β .

The Green function G used in WADA1 is a particular solution of the Laplace equation, which is regular throughout the fluid domain except at the source point (ξ, η) and directly satisfies the boundary conditions on the free surface (6), on the sea bottom (7), and at infinity (8). Denoting a field point by $z = x + iy$ (not to be confused with the z -coordinate in Fig. 1) and a source point by $\zeta = \xi + i\eta$, G can be written as (see Reference 2):

$$G(z, \zeta) = \text{Re} \frac{1}{2\pi} \left[\log(z - \zeta) - \log(z - \bar{\zeta}) + 2\text{P.V.} \int_0^\infty \frac{e^{-ik(z-\bar{\zeta})}}{\nu - k} dk \right] - i\text{Re} \left[e^{-i\nu(z-\bar{\zeta})} \right] \quad (11)$$

where Re indicates the real part, $\bar{\zeta}$ is the complex conjugate of ζ and P.V. indicates the Cauchy principal value.

The unknown source distribution $Q(\xi, \eta)$ along S is determined by applying the kinematic condition on the body surface (9). Substituting Equation (10) into Equation (9) yields the following integral equation for Q :

$$\frac{1}{2}Q(x, y) + \text{P.V.} \int_S Q(\xi, \eta) \frac{\partial G(x, y; \xi, \eta)}{\partial n(x, y)} ds(\xi, \eta) = -\frac{\partial \varphi_I(x, y)}{\partial n(x, y)} \quad (12)$$

Thus, the use of the Green function (11) reduces the boundary-value problem (5)–(9) in an infinite exterior domain to one involving only the body surface S , Equation (12).

For an arbitrary-shaped body, the integral equation (12) can be solved only through a numerical method. WADA1 uses a method of discretization known as Frank's close-fit method (Reference 1) in which a section contour S is represented by N straight-line segments S_j ($j = 1, 2, \dots, N$), and the source strength Q_j along an individual segment is assumed to be constant. The nodes, or the points at which the unknown values are sought, are taken to be at the midpoint of each segment.

Let $Q_j^{(m)}$ denote the complex source strength of the j^{th} segment S_j in the m^{th} mode of excitation, where $m = 1, 2$ for the horizontal excitation (asymmetric about the y -axis) and vertical excitation (symmetric about the y -axis) respectively. Then, for every ν and β , the integral equation (12) can be reduced to a set of N linear algebraic equations:

$$\sum_{j=1}^N I_{ij} Q_j^{(m)} = U_i^{(m)} \quad i = 1, 2, \dots, N \quad (13)$$

where I_{ij} are the influence coefficients defined by,

$$I_{ij} = \frac{1}{2} \delta_{ij} + K_{ij} \quad (14)$$

with δ_{ij} denoting the Kronecker delta function ($\delta_{ij} = 1$ if $i = j$ and $\delta_{ij} = 0$ otherwise) and

$$K_{ij} = \int_{S_j} \mathbf{n}_i \cdot \nabla G(x_i, y_i; \xi, \eta) ds(\xi, \eta). \quad (15)$$

The components $U_i^{(m)}$ of the normal velocity in the m^{th} mode of the incident wave at S_i are found from (3):

$$\begin{aligned} U_i^{(1)} &= -\mathbf{n}_i \cdot \nabla (\text{Re} \varphi_I) \Big|_{(x_i, y_i)} \\ &= a\omega e^{\nu y_i} [\sin \beta \cos(\nu x_i \sin \beta) n_{i1} + \sin(\nu x_i \sin \beta) n_{i2}] \end{aligned} \quad (16a)$$

$$\begin{aligned}
U_i^{(2)} &= -i\mathbf{n}_i \cdot \nabla (\text{Im}\varphi_I) \Big|_{(x_i, y_i)} \\
&= -i a \omega e^{\nu y_i} [\sin \beta \sin(\nu x_i \sin \beta) n_{i1} - \cos(\nu x_i \sin \beta) n_{i2}].
\end{aligned} \tag{16b}$$

Here (x_i, y_i) are the coordinates of the node situated at the midpoint of the i^{th} segment S_i , and $\mathbf{n}_i = (n_{i1}, n_{i2})$ is the normal unit vector to S_i pointing out of the fluid. For the details of evaluation of the influence coefficients I_{ij} , see Reference 1.

By solving the algebraic equation system (13), the source density $Q_j^{(m)}$ can be determined. Then the diffracted-wave potential $\varphi_D(x_i, y_i)$ for S_i is found by a direct quadrature via Equation (10), so that

$$\begin{aligned}
\varphi_D(x_i, y_i) &= \sum_{m=1}^2 \varphi_D^{(m)}(x_i, y_i) \\
&= \sum_{j=1}^N \left(\sum_{m=1}^2 Q_j^{(m)} \right) \Gamma_{ij}
\end{aligned} \tag{17}$$

where

$$\Gamma_{ij} = \int_{S_j} G(x_i, y_i, \xi, \eta) ds(\xi, \eta). \tag{18}$$

The total periodic wave-induced pressure P_W is obtained from the linearized Bernoulli equation, $P_W = -\rho \frac{\partial \Phi_W}{\partial t}$ for each node (x_i, y_i) , with Φ_W given in Equation (1). Thus,

$$\begin{aligned}
P_W(x_i, y_i, t) &= P_I(x_i, y_i, t) + P_D(x_i, y_i, t) \\
&= [p_I(x_i, y_i) + p_D(x_i, y_i)] e^{-i\omega t} \\
&= |P_W| e^{i\phi} e^{-i\omega t}
\end{aligned} \tag{19}$$

where p_I and p_D —the complex amplitudes of the incident-wave and diffracted-wave pressures, respectively—are given by

$$\begin{aligned}
p_I(x_i, y_i) &= i\omega \rho \varphi_I(x_i, y_i) \\
&= \rho g a e^{\nu y_i} e^{-i\nu x_i \sin \beta}
\end{aligned} \tag{20}$$

$$p_D(x_i, y_i) = i\omega \rho \varphi_D(x_i, y_i) \tag{21}$$

and $|P_W|$ and ϕ are respectively the magnitude and argument, or the amplitude and phase angle, of P_W .

4. IRREGULAR FREQUENCIES

Although physical problems always have unique solutions, the corresponding integral equations do not have this property and break down at a discrete infinite set of wave frequencies called irregular frequencies. This phenomenon was first pointed out by John³. To determine

the irregular frequencies for an arbitrary-shaped body, it is necessary to solve the adjoint interior problem; see, for example, References 1, 3, and 4. (For a rectangular cylinder such as shown in Fig. 3, the irregular frequencies can be expressed in a closed form as follows¹: $\omega_n = \sqrt{(n\pi g/B) \coth(n\pi T/B)}$, where ω_n is the n^{th} irregular frequency, $n = 1, 2, 3, \dots$. Here, B is the breadth and T is the draft of the cylinder.)

In practice, the influence-coefficient matrix (14), which approximates Equation (12) at discrete points, is often ill-conditioned even when ω lies in the vicinity of the irregular frequencies. To guard against the occurrence of this phenomenon, the user should carry out the computation at a few extra frequencies in the neighborhood of the frequencies of interest to make sure that no sudden discontinuities in the computed values occur when they are plotted against frequency. The user should disregard all results related to the discontinuities if they should occur.

5. DESCRIPTION OF INPUT

Data Set 1 (72 characters or less - FREE FORMAT)

TITLE - Brief description for identification purposes.

Data Set 2 (2 integers - FREE FORMAT)

ISYM - Control integer indicating whether the cross section possesses a symmetry with respect to the yz -plane:

ISYM = 0 No left-right symmetry;

ISYM = 1 Left-right symmetry exists.

NP - Number of offsets.

Note:

The number of segments should never be less than six on a half-section contour to ensure sufficient accuracy. (The size of a segment must be much less than the wavelength and the local radius of curvature of the sectional contour. Also, because the source strengths are averaged over each segment, the segment sizes should be made smaller near sharp corners.)

Data Set 3 (NP reals - FREE FORMAT)

(XA(I), I= 1, NP) - x -coordinates of the offsets.

(Note the remarks described in Data Set 4 below)

Data Set 4 (NP reals - FREE FORMAT)

(YA(I), I= 1, NP) - y -coordinates of the offsets.

Note:

(1) If $ISYM = 0$, then the first offset $(XA(1), YA(1))$ is the intersection of the free surface and the body contour in the left half-section, and going along in a counter-clockwise direction, the last offset $(XA(NP), YA(NP))$ is the intersection of the calm-water line and the body contour in the right half-section. The intersection of the contour and the y -axis must be included as an offset.

(2) If $ISYM = 1$, then the first offset $(XA(1), YA(1))$ is the intersection of the y -axis and the body contour, and going along in a counter-clockwise direction, the last offset $(XA(NP), YA(NP))$ is the intersection of the calm-water line and the body contour in the right half section.

(3) The computational algorithm in WADA1 requires that no two offsets in a half-section have identical vertical coordinates. For horizontal segments, this difficulty can be easily overcome by giving insignificantly small "artificial slopes" to the segments; compare Fig. 3(a) and Appendix A(b).

- | | |
|---------------------|---|
| Data Set 5 | (1 integer - FREE FORMAT) |
| NOX | - Number of wave frequencies. |
| Data Set 6 | (NOX reals - FREE FORMAT) |
| (XIB(I), I= 1,NOX) | - Values of the nondimensional frequency parameter:
$\xi_B = \frac{\omega^2 B}{2g}$, where ω is wave frequency, g the gravitational acceleration, and B the waterline breadth of the body. |
| Data Set 7 | (1 integer - FREE FORMAT) |
| NOB | - Number of wave directions. |
| Data Set 8 | (NOB reals - FREE FORMAT) |
| (BETA(I), I= 1,NOB) | - Directions β of wave propagation in degrees; see Fig. 1. |

Sample input is included in Appendix A.

6. DESCRIPTION OF OUTPUT

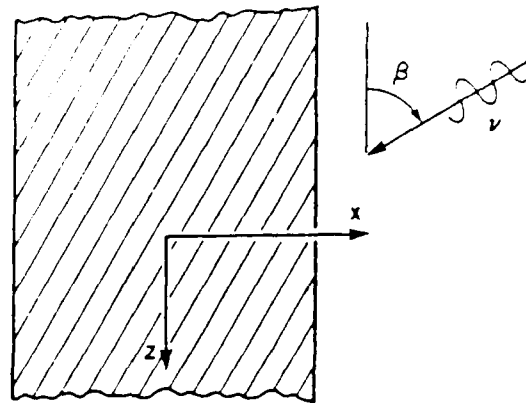
Appendix B shows an example of output corresponding to the sample input in Appendix A. The first part of the output is a printout of the input variables. They are followed by the values calculated by WADA1 for every combination of the wave frequency parameter ξ_B (XIB)

and the wave direction β (BETA). The real and imaginary parts of the complex amplitudes of the incident-wave pressure p_I (PI) and the diffracted-wave pressure p_D (PD) are printed, followed by the magnitude (MAG) $|P_W|$ and the argument (ARG) ϕ of the total wave-induced pressure P_W (PW) for each contour segment. Figures 2 and 3 show the plots of $|P_W|$ and ϕ .

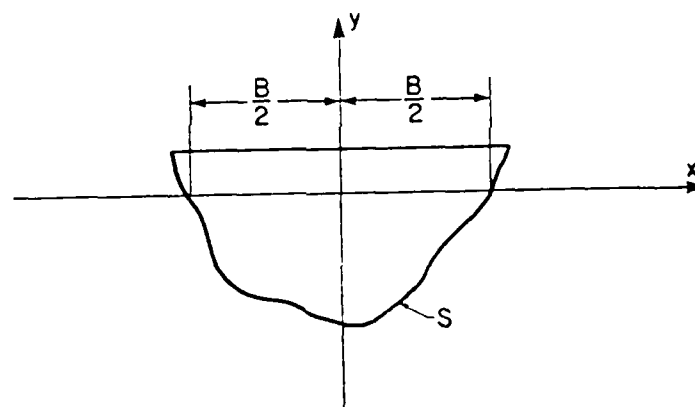
7. CONCLUDING REMARKS

The FORTRAN program WADA1 was developed for use in fluid-structure interaction problems. Using the source-distribution method, WADA1 calculates the hydrodynamic pressure exerted by regular incident waves and diffracted waves on arbitrary-shaped two-dimensional bodies fixed in the free surface of deep water. WADA1 requires a simple data input and involves a small number of unknowns. This is because the Green function used in WADA1 is a particular fundamental solution that directly satisfies the boundary conditions on the free surface, sea bottom, and at infinity, leaving only the body boundary to be discretized.

Since the solution's dependence on the longitudinal coordinate is neglected in the two-dimensional mathematical model for WADA1, the reliability of WADA1's prediction is expected to deteriorate as the direction of propagation of the incident wave deviates away from the direction of the x -axis.



(a)



(b)

FIG. 1. Body geometry and definition of coordinates:
(a) waterline plane and (b) cross section.

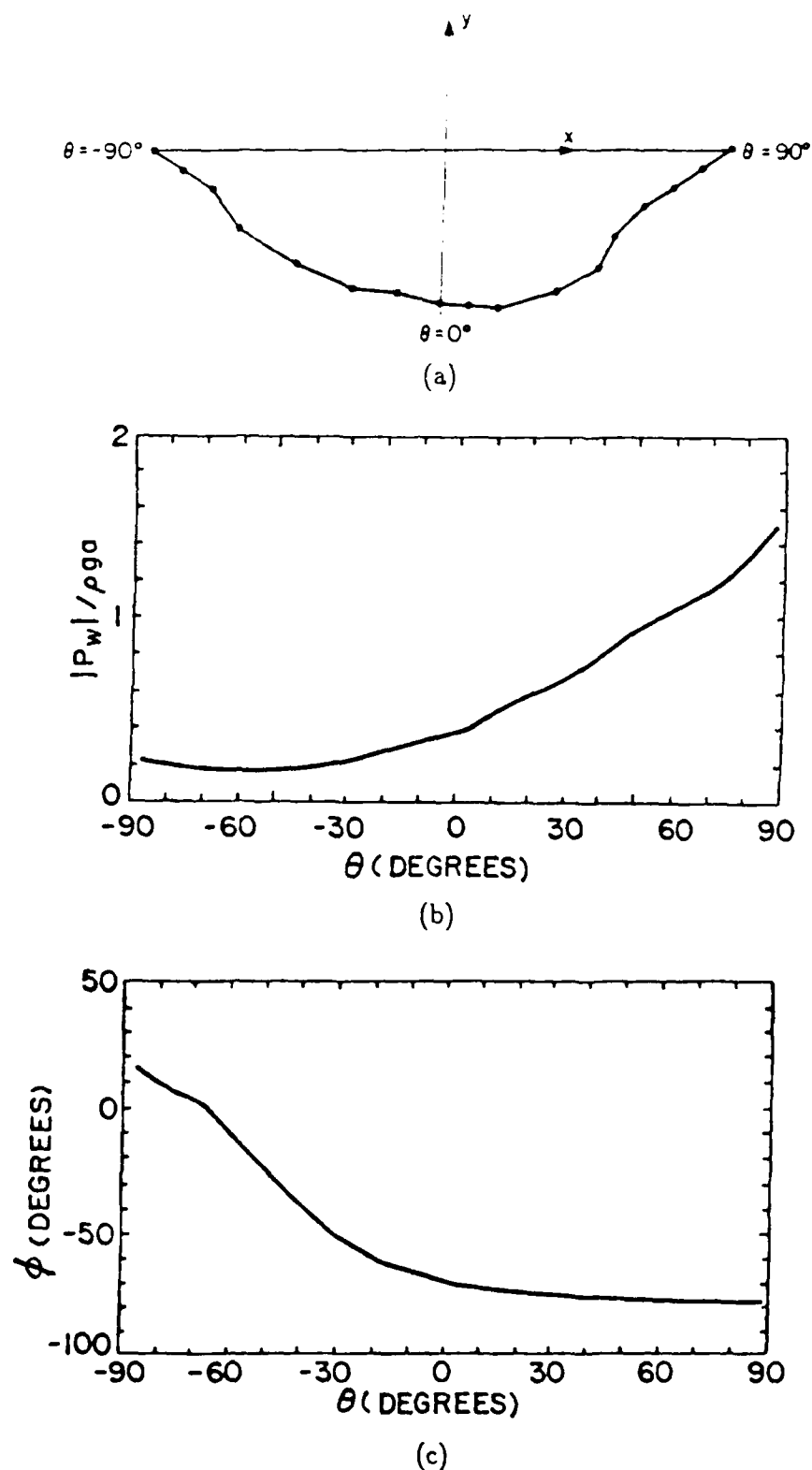


FIG. 2. Results for an asymmetric cylinder for $\xi_B = 1.0$, $\beta = 90^\circ$: (a) polygonal approximation of contour and offsets, (b) calculated pressure amplitude around the contour, and (c) pressure phase.

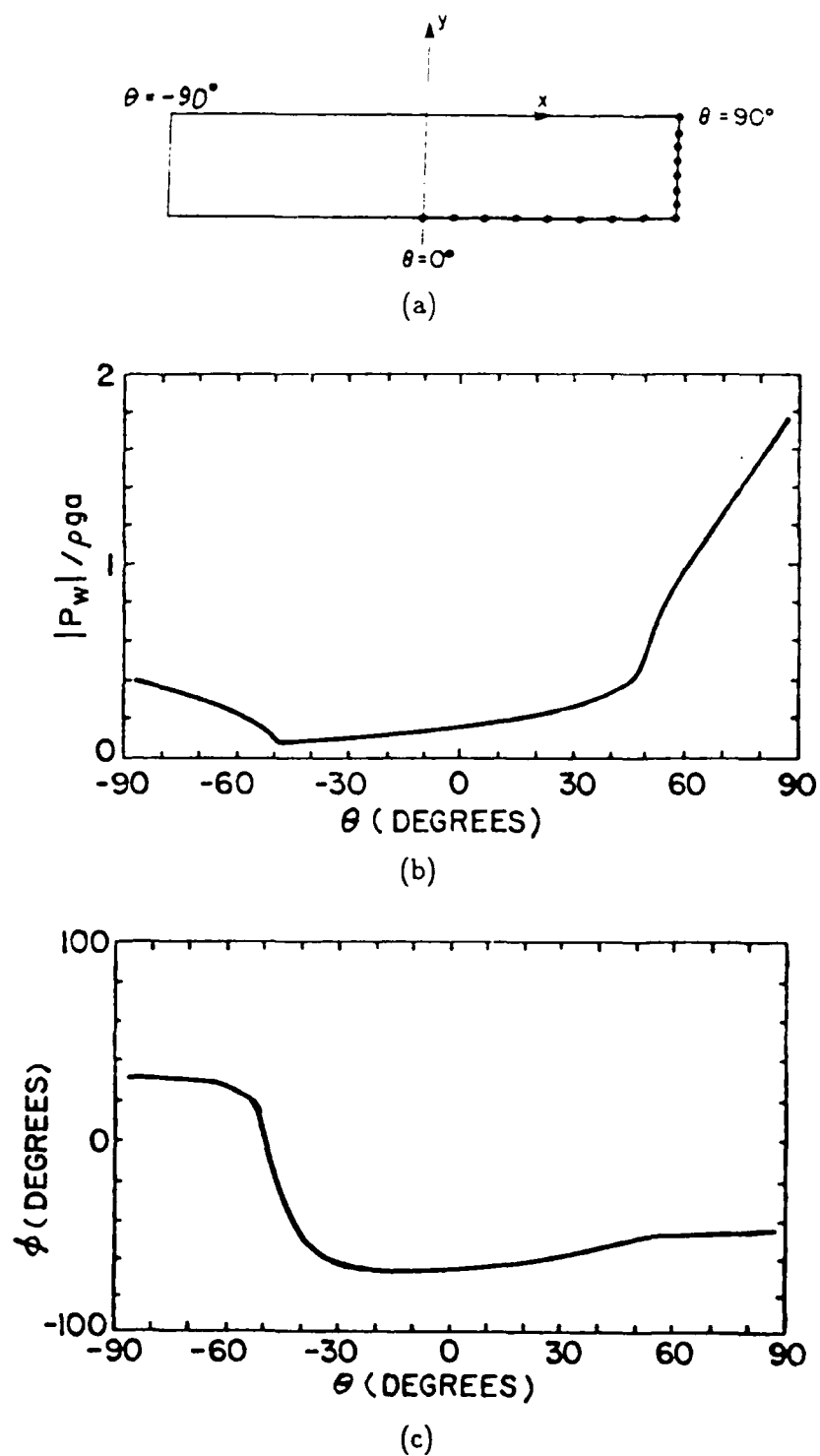


FIG. 3. Results for a symmetric cylinder for $\xi_B = 1.0$, $\beta = 135^\circ$: (a) polygonal approximation of contour and offsets, (b) calculated pressure amplitude around the contour, and (c) pressure phase.

APPENDIX A: SAMPLE INPUT

Data Set 1:	FLOATING ASYMMETRIC CYLINDER
Data Set 2:	0 17
Data Set 3:	-1. -0.9 -0.8 -0.7 -0.5 -0.3 -0.15 0. 0.1 0.2 0.4 0.55 0.6 0.7 0.8 0.9 1.0
Data Set 4:	0 -0.1 -0.2 -0.4 -0.58 -0.7 -0.72 -0.78 -0.79 -0.8 -0.72 -0.60 -0.45 -0.30 -0.20 -0.10 0.
Data Set 5:	1
Data Set 6:	1.0
Data Set 7:	1
Data Set 8:	90.

(a) AN ASYMMETRIC CYLINDER (SEE FIG. 2)

Data Set 1:	FLOATING RECTANGULAR CYLINDER
Data Set 2:	1 16
Data Set 3:	0. .156 .313 .469 .625 .781 .938 1.094 1.25 1.25 1.25 1.25 1.25 1.25 1.25 1.25
Data Set 4:	-1.001 -1.000875 -1.00075 -1.000625 -1.0005 -1.000375 -1.00025 -1.000125 -1. -0.857 -0.714 -0.571 -0.429 -0.286 -0.143 0.
Data Set 5:	1
Data Set 6:	1.
Data Set 7:	1
Data Set 8:	135.

(b) A SYMMETRIC CYLINDER (SEE FIG. 3)

APPENDIX B: SAMPLE OUTPUT

CALCULATION OF WAVE-INDUCED PRESSURES ON A CYLINDER FIXED IN THE FREE SURFACE

INPUT VALUES

FILEIN = WADA1.CYL IP = 1
TITL = FLOATING ASYMMETRIC CYLINDER
SYM = 0 NOP = 17

OFFSET	XA	YA
1	-1.00000	0.00000
2	-0.90000	-0.10000
3	-0.80000	-0.20000
4	-0.70000	-0.40000
5	-0.50000	-0.58000
6	-0.30000	-0.70000
7	-0.15000	-0.72000
8	0.00000	-0.78000
9	0.10000	-0.79000
10	0.20000	-0.80000
11	0.40000	-0.72000
12	0.55000	-0.60000
13	0.60000	-0.45000
14	0.70000	-0.30000
15	0.80000	-0.20000
16	0.90000	-0.10000
17	1.00000	0.00000

NOX = 1
XIB VALUE(S) = 1.00000

NOB = 1
BETA VALUE(S) = 90.0

CALCULATED VALUES

HALF BREADTH = 1.00000

PRESSURE DISTRIBUTION XIB = 1.00000 BETA = 90.0

SEG	REAL(P1)	IMAG(P1)	REAL(PD)	IMAG(PD)	MAG(PW)	ARG(PW)
1	0.5533	-0.7737	-0.3285	-0.7097	0.2338	15.8948
2	0.5681	-0.6466	-0.3655	-0.6131	0.2053	9.3931
3	0.5420	-0.5050	-0.3611	-0.5032	0.1809	0.5587
4	0.5056	-0.3459	-0.3532	-0.4177	0.1685	-25.2313
5	0.4857	-0.2053	-0.3484	-0.3706	0.2149	-50.2804
6	0.4793	-0.1097	-0.3453	-0.3669	0.2900	-62.4862
7	0.4710	-0.0354	-0.3353	-0.3609	0.3527	-67.3640
8	0.4555	0.0228	-0.3282	-0.3590	0.4025	-71.5523
9	0.4465	0.0675	-0.3063	-0.3986	0.4867	-73.2628
10	0.4468	0.1382	-0.2940	-0.4235	0.5821	-74.7834
11	0.4596	0.2364	-0.2850	-0.4851	0.7423	-76.3934
12	0.4964	0.3217	-0.2925	-0.5765	0.9211	-77.2115
13	0.5471	0.4159	-0.3205	-0.6086	1.0493	-77.5263
14	0.5698	0.5309	-0.3201	-0.6211	1.1787	-77.7669
15	0.5681	0.6466	-0.2916	-0.6487	1.3245	-77.9519
16	0.5533	0.7737	-0.2416	-0.7037	1.5100	-78.0873

(a) ASYMMETRIC CYLINDER (SEE FIG. 2)

CALCULATION OF WAVE-INDUCED PRESSURES ON A CYLINDER FIXED IN THE FREE SURFACE

INPUT VALUES

FILEIN = WADA1.RAT IP = 1

TITL = FLOATING RECTANGULAR CYLINDER

SYM = 1 NOP = 16

OFFSET	XA	YA
1	0.00000	-1.00100
2	0.15600	-1.00087
3	0.31300	-1.00075
4	0.46900	-1.00062
5	0.62500	-1.00050
6	0.78100	-1.00038
7	0.93800	-1.00025
8	1.09400	-1.00013
9	1.25000	-1.00000
10	1.25000	-0.85700
11	1.25000	-0.71400
12	1.25000	-0.57100
13	1.25000	-0.42900
14	1.25000	-0.28600
15	1.25000	-0.14300
16	1.25000	0.00000

NOX = 1

XIB VALUE(S) = 1.00000

NOB = 1

BETA VALUE(S) = 135.0

CALCULATED VALUES

HALF BREADTH = 1.25000

PRESSURE DISTRIBUTION XIB = 1.00000 BETA = 135.0

SEG	REAL(PI)	IMAG(PI)	REAL(PD)	IMAG(PD)	MAG(PW)	ARG(PW)
1	0.4486	0.0198	-0.3853	-0.1336	0.1659	-67.5952
2	0.4451	0.0594	-0.3673	-0.1115	0.1877	-65.5182
3	0.4381	0.0985	-0.3415	-0.0922	0.2138	-63.1248
4	0.4278	0.1368	-0.3074	-0.0771	0.2454	-60.6304
5	0.4141	0.1740	-0.2640	-0.0679	0.2846	-58.1790
6	0.3972	0.2099	-0.2093	-0.0672	0.3348	-55.8626
7	0.3771	0.2442	-0.1393	-0.0798	0.4019	-53.7336
8	0.3541	0.2765	-0.0406	-0.1207	0.5061	-51.7184
9	0.3617	0.3091	0.1194	-0.2582	0.7438	-49.7001
10	0.4055	0.3465	0.1925	-0.3441	0.9136	-49.1112
11	0.4547	0.3885	0.2508	-0.4176	1.0712	-48.8085
12	0.5096	0.4355	0.3050	-0.4894	1.2324	-48.6286
13	0.5711	0.4880	0.3581	-0.5631	1.4030	-48.5206
14	0.6404	0.5472	0.4118	-0.6405	1.5867	-48.4607
15	0.7180	0.6135	0.4665	-0.7223	1.7854	-48.4367

(b) SYMMETRIC CYLINDER (SEE FIG. 3)

-1	0.4486	-0.0198	-0.3960	-0.1573	0.1472	-69.0807
-2	0.4451	-0.0594	-0.3996	-0.1818	0.1306	-69.6301
-3	0.4381	-0.0985	-0.3963	-0.2062	0.1155	-68.7536
-4	0.4278	-0.1368	-0.3861	-0.2293	0.1015	-65.7268
-5	0.4141	-0.1740	-0.3689	-0.2503	0.0888	-59.3571
-6	0.3972	-0.2099	-0.3443	-0.2680	0.0786	-47.7169
-7	0.3771	-0.2442	-0.3114	-0.2805	0.0750	-28.8999
-8	0.3541	-0.2765	-0.2663	-0.2826	0.0880	-3.9509
-9	0.3617	-0.3091	-0.2232	-0.2597	0.1471	19.6045
-10	0.4055	-0.3465	-0.2320	-0.2654	0.1916	25.0661
-11	0.4547	-0.3885	-0.2493	-0.2810	0.2319	27.6386
-12	0.5096	-0.4355	-0.2719	-0.3032	0.2720	29.0904
-13	0.5711	-0.4880	-0.2997	-0.3318	0.3132	29.9311
-14	0.6404	-0.5472	-0.3328	-0.3669	0.3566	30.3797
-15	0.7180	-0.6135	-0.3715	-0.4092	0.4022	30.5362

(b) SYMMETRIC CYLINDER - CONTINUED

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This technical memorandum describes the FORTRAN computer program WADAl (Wave Diffraction Analysis - Version 1), which calculates the pressure induced by the diffraction of regular incident waves on arbitrary-shaped two-dimensional cylinders fixed in the free surface of deep water. Based on the source-distribution method, WADAl solves the integral equation for the linear diffraction problem by Frank's close-fit method.

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